ATTACHMENT 1

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DRAFT NEW RECOMMENDATION ITU-R SF.[Doc. 4/85-9/108]*

Example approach for determination of the composite area within which interference to fixed service stations from earth stations on board vessels when operating in motion near a coastline would need to be evaluated

(Questions ITU-R 226/9 and ITU-R 254/4)

Summary

This Recommendation provides an example approach for the determination of a composite area within which interference to fixed service stations from earth stations on board vessels (ESVs) when operating in motion near a coastline would need to be coordinated.

This is in response to *resolves* 2 of Resolution 82 (WRC-2000) which calls upon ITU-R to urgently develop Recommendations on methods for coordination between terrestrial services and ESVs.

The ITU Radiocommunication Assembly,

considering

a) that WRC-2000 adopted Resolution 82 concerning provisions for earth stations on vessels (ESVs) operating in the bands 3 700-4 200 MHz and 5 925-6 425 MHz;

b) that *resolves* 1 and 2 of that Resolution calls for ITU-R to urgently study regulatory, technical and operational constraints which would need to be applied to ESV operations, including those transmitting in the 14 GHz band;

c) that the use of ESVs will not require coordination when operating beyond a minimum distance from shore within which there is a potential for causing unacceptable interference to stations in the fixed service;

d) that there is a need for ESVs operating within the minimum distance referred to in *considering* c) to not cause unacceptable interference to terrestrial stations;

e) that ESVs have preliminary technical characteristics such as those described in draft Recommendation ITU-R S.[Doc. 4/57],

recommends

1 that Annex 1 may be used as an example approach to determine the composite area within which interference to fixed stations from proposed operations of in-motion ESVs should be evaluated.

* This Recommendation should be brought to the attention of Radiocommunication Study Group 8 and Special Committee.

ANNEX 1

Example approach for the determination of the composite area within which interference to fixed service stations from earth stations on board vessels when operating in motion near a coastline needs to be evaluated

1 Introduction

Earth stations on vessels (ESVs) are potential sources of interference for stations in the fixed service operating in the same band. This Annex describes a method that may be used by administrations to determine the appropriate areas within which the operation of ESVs must be coordinated with stations of the fixed service when that operation is within a distance from the shore, as defined in draft new Recommendation ITU-R SF.[4/95-9/154] of any administration.

The potential interference effects from ESVs can be avoided by examining potential interference to receivers operating in the same frequency band located within the composite area determined for the motion of the ship near the coast. The use of particular frequencies may need to be avoided where the predicted worst-case interference to FS operations on such frequencies exceeds the specified interference criteria.

2 ESV operation close to shore

When vessels equipped with earth stations are operating close to shore, determination of the area within which unacceptable interference may occur is a critical step in the process to ensure that such unacceptable interference does not occur. Determination of this composite area requires knowledge of the limits of the position of the vessel as it approaches land, enters a port or harbour, and proceeds to the vessel's final stationary point at the dock or at anchor. Similar limitations must be defined for the ESV operations as the vessel leaves its stationary position in the port and proceeds to the open sea.

Maritime navigation regulations define the requirements for vessel motion within the sea-lanes and port channels. A vessel larger than 300 gross tonnage must stay within the area known as the sea-lanes as it approaches a port. Once inside a port or harbour, the vessel must follow the port channels to its final stationary position at the dock or mooring at a pre-designated stopping point. The sea-lanes and port channels are clearly marked on the water with buoys and other defined aids to navigation. They are also clearly designated on maritime charts published by local and international regulatory authorities.

Once within the sea-lanes leading to a port or harbour and the channels within that port, a vessel may not go outside the marked areas, nor may it stop or anchor at any point except as directed by the local authorities. These limitations on vessel motion define the extremes of position for all larger vessels, including those equipped with ESVs. These extremes of position (that is, the administration-mandated limits of permissible vessel motion) define the "operating contour" for all larger vessels operating in a particular port or harbour.

The information defining the maximum vessel operating area within a sea-lane or port channel is readily available from published maps, charts, and regulatory authorities. Identification of this mandatory operating contour, which cannot be violated by an ESV-equipped vessel, provides the basis for determining the area within which there is a potential for interference when near shore and thus defines the composite area within which coordination with fixed service stations needs to take place.

3 Determination of the composite area

The determination of the composite area is carried out in two stages. The first is the determination of a set of areas at specific points within the ship's operating contour. The second is the development of the composite area from these individual point areas.

3.1 Determination of areas at specific points

After determining the operating contour from published maps, charts and regulatory authorities for a vessel operating near to shore, the next step is to determine the areas associated with a representative set of positions in or on the operating contour. These are the individual point areas. These individual areas are developed by determining the required coordination distance at a set of azimuth angles. The coordination distance is the distance from an earth station beyond which interference to or from a terrestrial station may be considered to be negligible.

These individual point coordination distances can be computed using the minimum permissible transmission loss methodology contained in Recommendation ITU-R SM.1448, for fixed points in section 3.2 below.

The calculation of an accurate distance requires specific information about the operating characteristics of the ESV and the azimuth and elevation of the antenna for the satellite(s) to be used in that particular port. The operating parameters of the earth station do not change significantly as the vessel moves to a stationary position within the port or harbour and, therefore, a single set of parameters may be used to compute the minimum permissible transmission on a given azimuth loss for the entire operating contour within a specific port and when known the specific fixed service parameter values may also be used in developing the coordination distance.

However, the percentage of the path that is over water varies from 100% over water when the vessel is at the full coordination distance from the port to almost entirely over land when it is docked in the harbour. As the percentage of land in the path increases, the coordination distance will decrease.

3.2 Determination of the composite area for coordination

The composite area within which earth stations on board vessels (ESV) operated in-motion near a coast can be determined using, for example, the procedures given in Recommendation ITU-R SM.1448 and a knowledge of the operating contour for that specific port. In addition, it is necessary to identify a set of break points along the operating contour representing the limits of vessel position and where the sea-lanes and port channels change direction. A coordination distance is then computed for all azimuths around these break points to determine the coordination area for a specific break point. These are the circled numbers in Figure 1.

The coordination areas computed for each break point can be drawn on a chart containing the relevant operating contour or generated by a computerized graphical information system using the same principles. Figure 1 shows an example of such coordination areas.

In Figure 1, the operating contour is represented by the funnel-shaped figure that leads from the open ocean into the harbour. The break points of the operating contour are numbered in a systematic fashion as shown in Figure 1. The operating contour starts at the minimum distance from shore where the level of interference to fixed service systems is not expected to exceed permissible levels. This would include islands, man-made offshore structures and peninsulas, if applicable. If the coastline is highly irregular (i.e. with deviations greater than 10 km of the entrance to the port), then a series of straight-line segments may be used, each one drawn at a distance from the nearest point of land.

It will often be the case that the distance from the shore to the last sea-lane marker, called the outer marker, is less than the distance beyond which coordination is not necessary. Beyond the outer marker ships may proceed in any direction that may be safely navigated. Therefore, in such cases the operating contour must be extended from the outer marker to the limit in such a fashion as to include all possible routes that ships with ESVs can and will use. Moreover, the limits of the operating contour thus extended must be clearly marked on the chart so that the limits of the area considered in the coordination procedure are easily understood.

Figure 1 gives an example of this procedure. In this figure break points numbered 2 and 9 are the outer markers of the sea-lanes. The operating contour has been extended to break points numbered 1 and 10. The crosshatched area outside the limits of the operating contour indicates that the use of the ESV has not been examined for potential interference in this area. Therefore, the ESV may not be used if the ship uses an approach route to the port that is outside of the indicated operating contour.

As mentioned previously, the numbered points along the operating contour are the break points where the individual coordination areas have been calculated. Two such example coordination areas are shown at break points number 2 and 4. In both cases the coordination area is larger along the boresight of the antenna pointing towards the satellite(s) to be used by the ESV. At break point number 2 the transmission path is mostly over water and, therefore, the coordination area for this point is larger than the coordination area at break point number 4 where the transmission paths are mostly over land. The extremes of the individual coordination areas for all of the points are then joined to form the composite area for the ESV as it moves within the distance beyond which coordination is not required to the stationary position in the harbour. (Where multiple paths exist from the port to the open sea, select the points that enclose the greatest area (i.e. the points that are the greatest distance from the channels and sea-lanes in the direction of land) so as to be sure to include the full coordination distance for any possible position of the vessel within the operating contour.)

The area enclosed by this boundary and the outer boundary line is the composite area of an ESV for a specific port or harbour within which coordination with fixed stations needs to take place.

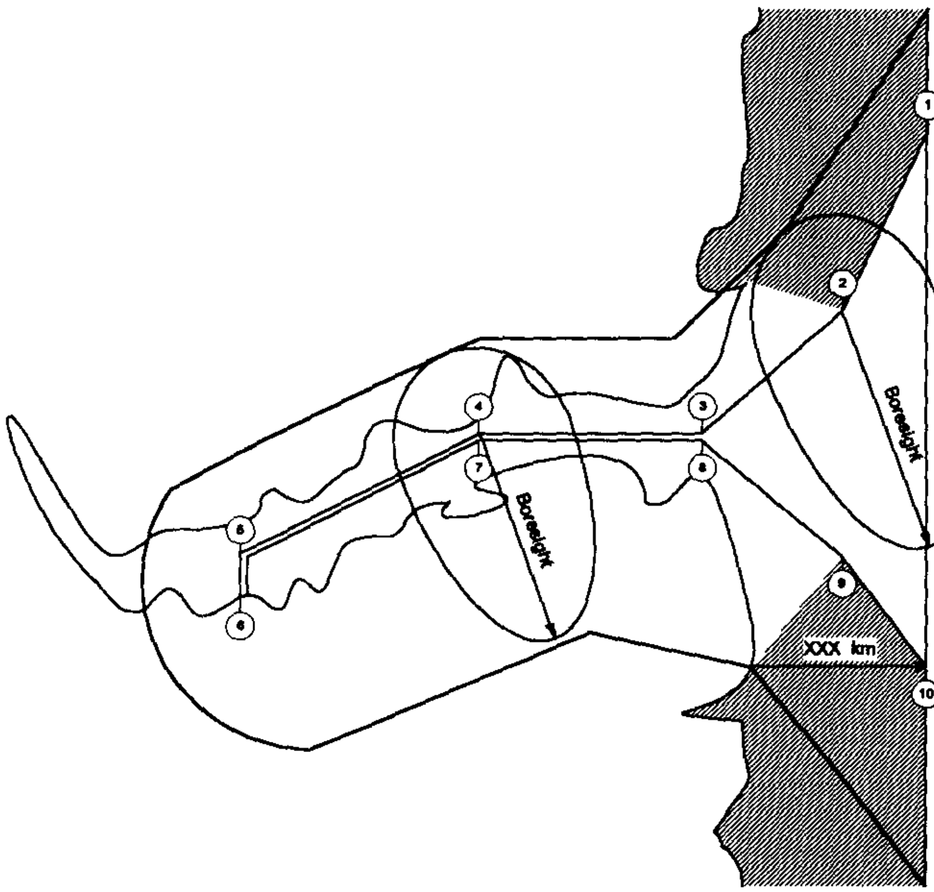

FIGURE 1

Example overall composite area

ATTACHMENT 2

INTERNATIONAL TELECOMMUNICATION UNION

RADIOCOMMUNICATION STUDY GROUPS

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Working Party 4-9S

DRAFT NEW RECOMMENDATION ITU-R SF.[4-9S/ESV-A]

The minimum distance from the coastline[1] beyond which in-motion earth stations located on board vessels would not cause unacceptable interference to the fixed service in the bands 5 925-6 425 MHz and 14-14.5 GHz

(Questions ITU-R 226/9 and ITU-R 251/4)

The ITU Radiocommunication Assembly,

considering

a) that the technology exists which permits the use of FSS networks by earth stations on board vessels (ESV) in the bands 5 925-6 425 MHz and 14-14.5 GHz (Earth-to-space);

b) that ESVs have the potential to cause unacceptable interference to fixed service systems in these bands;

c) that ESV operations require considerably less than the full bandwidth in this FSS allocation and only a portion of the visible geostationary arc;

d) that in order to ensure the protection and future growth of the FS, the ESV must operate with certain operational constraints;

e) that a minimum distance from the coastline could be determined beyond which the ESV will not cause unacceptable interference to the fixed service in these bands;

g) that the minimum distance in e) may be based on administrative and technical considerations,

noting

that some administrations have been operating ESVs for some years under Radio Regulations (RR) No. 4.4,

[1] Note: The definition of the coastline is a matter to be decided by the Administration concerned.

recommends

1 that, in the band 5 925-6 425 MHz, the minimum distance from the coastline beyond which in-motion ESVs would not cause unacceptable interference to the FS is 300 km (based on the parameters of Table 1, Annex 1);

2 that, in the band 14-14.5 GHz, the minimum distance from the coastline beyond which in-motion ESVs would not cause unacceptable interference to the FS is 125 km in bands shared with the FS (based on the parameters of Table 1, Annex 1).

NOTE 1 – The minimum distance values remain only valid for an antenna size of 2.4 m and 1.2 m, for the 5 925-6 425 MHz and 14.0-14.5 GHz bands, respectively. The impact of the antenna diameter on the number of vessels considered in the calculation need further review.

ANNEX 1

Method to use in development of a minimum distance for the 5 925-6 425 MHz and 14-14.5 GHz bands

1 Method to determine the distance

The maximum permissible interference power is

$$I_{max} = \left(\frac{I}{N}\right)_{th} + 10\log_{10}\left(kT_{FSR}B_{FSR}\right) \text{ (dBW)} \tag{1}$$

where:

$\left(\frac{I}{N}\right)_{th}$: interference to thermal noise power ratio defined in interference criterion (dB)

k: Boltzman's constant (W/K/Hz)

T_{FSR}: system noise temperature of the FSR (K)

B_{FSR}: bandwidth of FSR (Hz).

Once the short-term interference criterion has been defined, the *minimum permissible transmission loss* is given by subtracting the FSR's (Fixed Service Receiver) *permissible interference power level* from the sum of the ESV's *effective isotropic radiated power* (*e.i.r.p.*) *in the direction of the FSR* and the FSR's *average antenna gain in its –10 dB beamwidth*. The minimum permissible transmission loss is therefore given by:

$$L_{b,min}(p_S) = (P_{t,max} + G_t + G_{r,AVE} - I_{max}) - F \tag{2}$$

where:

$L_{b,min}$: minimum required basic transmission loss (dB)

$P_{t,max}$: maximum transmit power at the ESV antenna input flange (dBW)

G_t: ESV antenna gain in the direction of the FS receiver (FSR) (dBi)

$G_{r,AVE}$: average gain of the FSR antenna within its −10 dB beamwidth (dBi)

I_{max}: maximum permissible interference power, (dBW)

F: loss in the feed from the FSR antenna to the low noise amplifier (dB).

Because the ESV is not always present, it is not appropriate to use the *short-term interference objective time percentage*, p_s, directly as the propagation model input parameter, p, which is the *time percentage for which the required minimum transmission loss is not exceeded* (e.g. in Recommendations ITU-R P.452 or ITU-R P.620). The appropriate p depends on how much time the ESV spends within the −10 dB beamwidth of the FSR. But, as is clear in Figure 1, this amount of time depends on the distance from the ESV to the FSR. Since p depends on this distance and vice versa, an iterative method for determining the minimum d_{xxx} that satisfies the short-term interference criteria is unavoidable.

Figure 2 presents a flow chart that details the iterative procedure. The procedure can be initiated under the assumption that the ESV is always present, yielding $d_{xxx}(0)$. The next iteration determines how much time the ESV would spend in the −10 dB beamwidth of the FSR at the distance $d_{xxx}(0)$ and then calculates $d_{xxx}(1)$ based on the resulting value of p. The procedure continues until the difference between d_{xxx} on successive iterations is less than a threshold, δ. It is recommended that δ = 3 km.

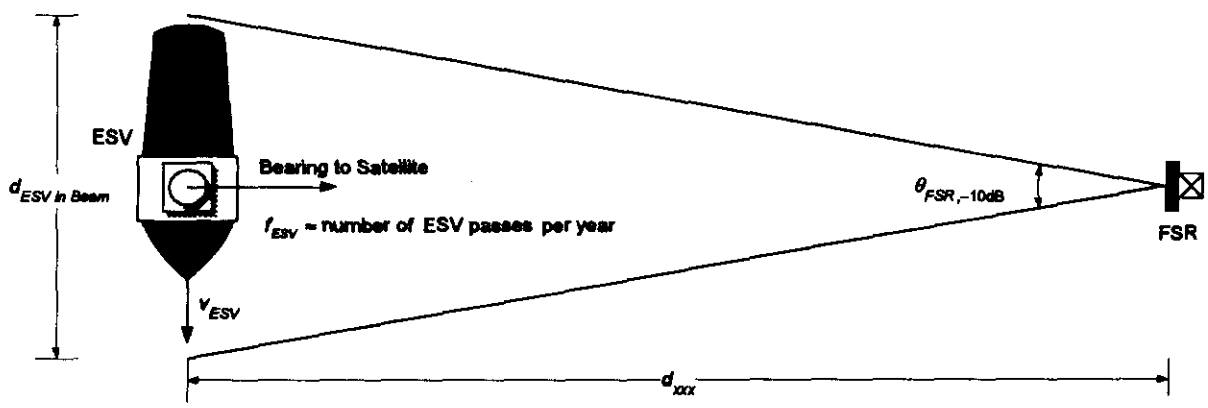
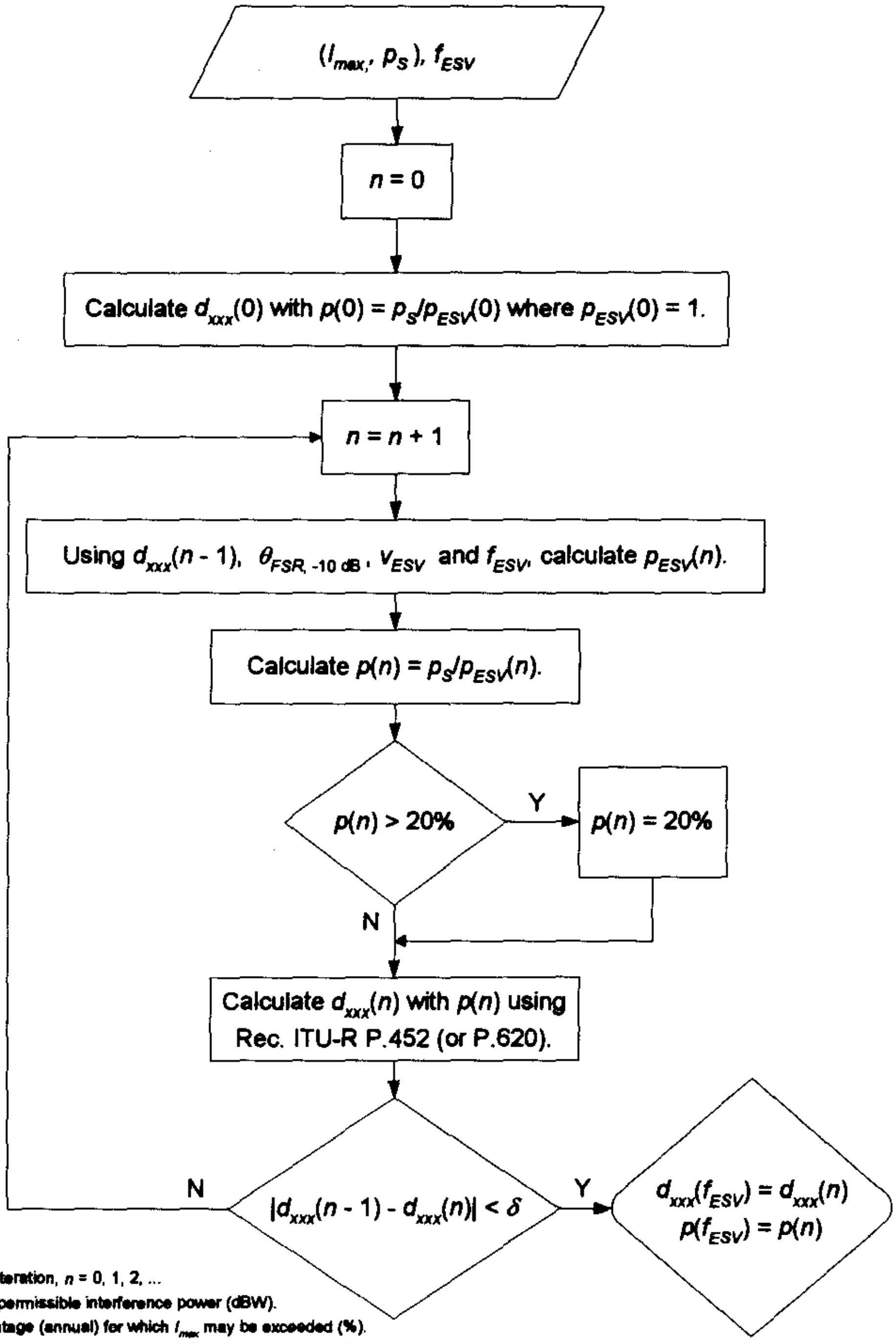


FIGURE 1

Geometry of modelled scenario



NOTES:

- n = stage of the iteration, n = 0, 1, 2, ...
- I_{max} = Maximum permissible interference power (dBW).
- p_S = Time percentage (annual) for which I_{max} may be exceeded (%).
- p_{ESV} = Time percentage (annual) for which ESVs are present (%).
- p = Time percentage (annual) for which minimum required transmission loss is not exceeded (%).
- δ = 3 km is recommended (distances <3km are not recommended due to the interaction between the iterations of the propagation model and the iterations of this method.

FIGURE 2

Flow chart of iterative process

2 Parameter values

The parameter values below do not necessarily represent the worst case of each parameter. However, they are used to develop a representative set of characteristics which are considered to provide adequate protection to the FS from potential interference from ESVs.

2.1 Parameter values for the 6 GHz band

TABLE 1

Parameters used in calculating the minimum distance

Earth station on vessel (ESV) parameters		
Parameter	**Value**	**Comment**
Frequency of operation, f (MHz)	6 000	
Antenna height above sea level, h_u (m)	40	
Elevation angle to satellite, φ (deg)	>10	See footnote 1
Horizon gain angle, θ_h (deg)	0	Equation (24) of Recommendation ITU-R SM.1448 = 0 in worst case
Maximum transmit power at input to antenna, $P_{t,\,max}$ (dBW)	16.7	
Minimum antenna diameter, D_{min}(m)	2.4	
Ant. Gain in direction of FSR, $G_t = G_{ESV}(\varphi)$ (dBi)	+4 to −10	Equation (33) of Recommendation ITU-R SM.1448
Maximum occupied bandwidth, B_{ESV} (MHz)	2.346	
Data rate, R_{ESV} (Mbit/s)	1.544	
Ship's speed, v_{ESV} (km/hr)	18.3	Typical minimum value when out to sea (10 knots)
Frequency of passage, f_{ESV} (passes/year) which fall into FSR receiver channel bandwidth	variable	See section 3.5 below.

Fixed-service receiver (FSR) parameters		
Parameter	**Value**	**Comment**
Frequency of operation, f (MHz)	6 000	Equal to ESV value
Antenna height above ground, h_{rg} (m)	70	
Ground height above mean sea level, h_g (m)	50	
Antenna height above mean sea level, $h_{rs} = h_g + h_{rg}$ (m)	120	Calculation using values above
Max boresight antenna gain, $G_r = G_{FSR}(0)$ (dBi)	45	Recommendation ITU-R F.758
−10 dB beamwidth, $\theta_{FSR,\,-10\,dB}$ (deg)	1.72	Recommendation ITU-R F.699
Ave. ant. gain in −10 dB beamwidth, $G_{r,\,AVE}$ (dBi)	42.5	Calculated
Feeder loss, F (dB)	3	
Receiver bandwidth, B_{FSR} (MHz)	11.2	
Noise temperature, T_{FSR} (Kelvin)	750	Recommendation SM.1448
Data rate, R_{FSR} (Mbit/s)	34	
Reference path length (km)	25	
Short-term interference objective		
Interference criteria I/N_{th}, (dB).	• I/N = 23 dB not to be exceeded for more than 1.2×10^{-5}% of the time for the SES level. • I/N = 19 dB not to be exceeded for more than 4.5×10^{-4}% of the time for the ES level.	These figures are based on a net fade margin of 24 dB referenced to the 10^{-3} BER level. Note that the interference criterion associated with the ES level is the more stringent criterion and hence this is used to determine the required distance
Permissible interference power level, I_{max} (dBW)	−110.4	$= 10.\log(k.T_{FSR}.B_{FSR}) + I/N_{th}$
Time percentage for which $P_{interference,S}$ may be exceeded, p_S (%)	4.5×10^{-4}%	
Calculation (in dB) of minimum permissible transmission losses		
Loss, $L_{b,\,min}(p_S)$ (dB)	calculated	See equation (2)
Range of ESV from FSR, d_{xxx} (km)	calculated	
Distance travelled by ESV through −10 dB beamwidth, $d_{ESV\ in\ Beam}$ (km)	calculated	$= 2d_{xxx}\tan(\theta_{FSR,\,-10dB}/2)$

Time spent by ESV in −10 dB beamwidth, $t_{ESV\ in\ Beam}$ (hours)	calculated	$= d_{ESV\ in\ Beam}/v_{ESV}$
ESV interference percentage, p_{ESV} (%)	calculated	$= (f_{ESV} t_{ESV\ in\ Beam}/8760) \times 100\%$
Time percentage for which $L_{b,\ min}(p_S)$ is not exceeded, p (%)	calculated	$= (p_S/p_{ESV}) \times 100\%$

2.2 Parameter values for the 14 GHz band

TABLE 2

Parameters used in calculating the minimum distance

Earth station on vessel (ESV) parameters		
Parameter	**Value**	**Comment**
Frequency of operation, f (MHz)	14 250	
Antenna height above sea level, h_{ts} (m)	40	
Elevation angle to satellite, φ (deg)	>10	See footnote 1
Horizon gain angle, θ_h (deg)	0	
Maximum transmit power at input to antenna, $P_{t,\ max}$ (dBW)	12.2	
Minimum antenna diameter, D_{min}(m)	1.2	
Antenna gain in direction of FSR, $G_t = G_{ESV}(\varphi)$ (dBi)	+4 to −10	
Maximum occupied bandwidth, B_{ESV} (MHz)	2.346	
Data rate, R_{ESV} (Mbit/s)	1.544	
Ship's speed, v_{ESV} (km/hr)	18.3	Typical minimum value when out to sea (10 knots)
Frequency of passage, f_{ESV} (passes/year) which fall into FSR receiving channel bandwidth	variable	See section 3.6 below.

Fixed-service receiver (FSR) parameters		
Parameter	**Value**	**Comment**
Frequency of operation, f (MHz)	14 250	Equal to ESV value
Antenna height above ground, h_{rg} (m)	30	
Ground height above mean sea level, h_g (m)	50	
Antenna height above mean sea level, $h_{rs} = h_g + h_{rg}$ (m)	80	Sum of values above
Max boresight antenna gain, $G_r = G_{FSR}(0)$ (dBi)	43	For 1.2 m antenna
−10 dB beamwidth, $\theta_{FSR,\,-10\,dB}$ (deg)	2.2	Calculated from Recommendation ITU-R F.1245.
Ave. ant. gain in −10 dB beamwidth, $G_{r,\,AVE}$ (dBi)	40.5	Calculated
Feeder loss, F (dB)	3	
Data rate (Mbit/s)	34	
Receiver bandwidth, B_{FSR} (MHz)	14	For 34 Mbit/s link
Net fade margin referenced to the 10^{-3} BER level (dB)	24	
I/N applicable to ES criterion (I/N_{th})	19	
Noise figure, NF (dB)	4.5	
Short-term interference objective		
Permissible interference power level, $P_{interference,\,S}$ (dBW)	−109	$=10.\log(k.T.B_{FSR}) + NF + I/N_{th}$
Time percentage for which I_{max} may be exceeded, p_S (%)	2.7×10^{-4}	
Calculation (in dB) of minimum permissible transmission losses		
Loss, $L_{b,\,min}(p_S)$ (dB)	Calculated	See equation (2)
Calculation of applicable time percentage for which minimum propagation loss is not exceeded considering that ESVs are not always present		
Sample range of ESV from FSR, d_{xxx} (km)	calculated	
Distance travelled by ESV through −10 dB beamwidth, $d_{ESV\,in\,Beam}$ (km)	calculated	$= 2d_{xxx}\tan(\theta_{FSR,\,-10dB}/2)$
Time spent by ESV in −10 dB beamwidth, $t_{ESV\,in\,Beam}$ (hours)	calculated	$= d_{ESV\,in\,Beam}/v_{ESV}$
ESV interference percentage, p_{ESV} (%)	calculated	$= (f_{ESV}t_{ESV\,in\,Beam}/8\,760) \times 100\%$
Time percentage for which $L_{b,\,min}(p_S)$ is not exceeded, p (%)	calculated	$= (p_S/p_{ESV}) \times 100\%$

3 Discussion of assumptions and parameter values

3.1 Maximum ESV transmit power

The value of $P_{t,\,max}$ is the power at the antenna input and not the maximum output power from the ESV transmitter high power amplifier (HPA). The value of $P_{t,\,max}$ must take into account the sum of losses incurred in all waveguides, cables and rotary joints that may be in the signal path between the HPA output and the antenna input flange.

$P_{t,\,max}$ is the assumed power level at the input of the antenna of an ESV transmitting at the maximum bit rate and hence represents the worst case value of any ESV. For the 6 GHz band $P_{t,\,max}$ = 16.7 dBW and for the 14 GHz band $P_{t,\,max}$ = 12.2 dBW. However, the value of transmitter power strongly depends on the required bit rate and on other system characteristics. For 6 GHz ESVs the transmitter power may be about 0 dBW (16.7 dB less than $P_{t,\,max}$) for low bit-rate carriers and for 14 GHz ESVs the transmitter power may be as low as about –13 dBW (25.2 dB less than $P_{t,\,max}$) for low bit-rate carriers.

3.2 ESV gain in the direction of the fixed service receiver

Under the worst-case assumption that the azimuth angles from the ESV to the FS receiver (FSR), and from the ESV to the ESV's desired satellite are equal, G_t is defined as follows:

$$G_t = G_{ESV}(\theta_{ESV}) \quad \text{(dBi)} \tag{3}$$

where:

$G_{ESV}(\theta)$: ESV antenna gain at off-boresight angle θ, at the transmit frequency (dBi)

θ_{ESV}: elevation angle of the ESV antenna with respect to the horizontal (degrees)

In any other case, G_t would be given by $G_{ESV}(\theta')$ where θ' is the angle between the ESV antenna boresight and the horizon in the azimuth direction of the FSR ($\theta' > \theta_{ESV}$). $G_{ESV}(0)$ is the boresight (maximum) gain of the ESV antenna and θ is measured with respect to the antenna boresight.

Calculation results are presented for example discrimination angles of 10°, 20° and 36°. The results for 36° are also applicable for all discrimination angles exceeding 36°. The probability of occurrence of each value depends on the relative azimuth of the ESV with regards to the FS direction, the minimum ESV elevation to consider, and finally the latitude under which the ESV operates, which controls the maximum ESV elevation.

It is therefore possible to calculate the antenna discrimination for all the geometrical cases taking into account the ESV azimuth relative to the FSR (from 0 to 360°) and its elevation (from the minimum elevation to the maximum elevation depending, for the latter, on the considered latitude).

On this basis, the distributions of such antenna discrimination for certain latitude are given in Figure 3 below for an assumed minimum elevation of 10°.

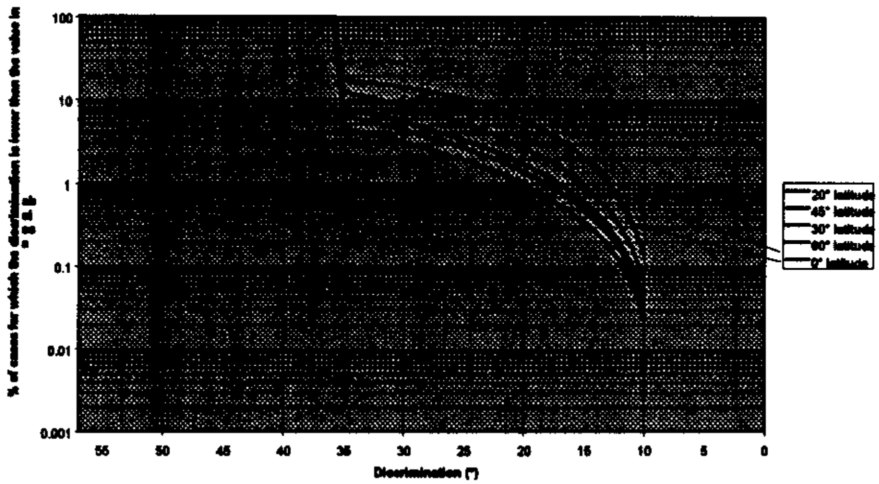


FIGURE 3

Distribution of antenna discrimination for different latitudes

As confirmed in Table 3 below, it shows that the occurrence of antenna discrimination lower than 36° is small, for lower latitudes in particular. A discrimination angle less than 36° occurs in 17.5% of the cases (at 60° latitude) to 4.6% of the cases (at 0° latitude). In addition, a discrimination lower than 20° only represents 2.3% at 45° latitude. It can be noted from Figure 3 that (for a 10° minimum elevation), 10° discrimination only occurs in one improbable case for which the FS and ESV azimuth are aligned.

TABLE 3

ESV antenna discrimination angle for different latitudes

	[illegible]	[illegible]	[illegible]
[illegible]	95.4	2.8	0.8
[illegible]	93.6	4	1.2
[illegible]	92.1	4.9	1.4
[illegible]	87.6	7.7	2.3
[illegible]	82.5	13.5	4.8

Noting the percentages in Table 3, distance results for 20° and 36° discrimination only are provided.

3.3 Propagation model

Results are presented based on propagation models in Recommendations ITU-R P.452 and ITU-R P.620.

Results are presented for two example latitudes, 45° and 20°.

3.4 Location of FSR

The calculation methodology is based on analysis of interference from the ESV into the main lobe of the FSR antenna. Results are presented for two cases: the FSR located on the coast (0 km inland) and the FSR located some distance inland (25 km inland for the 6 GHz band and 15 km for the 14 GHz band) as shown in Figure 4.

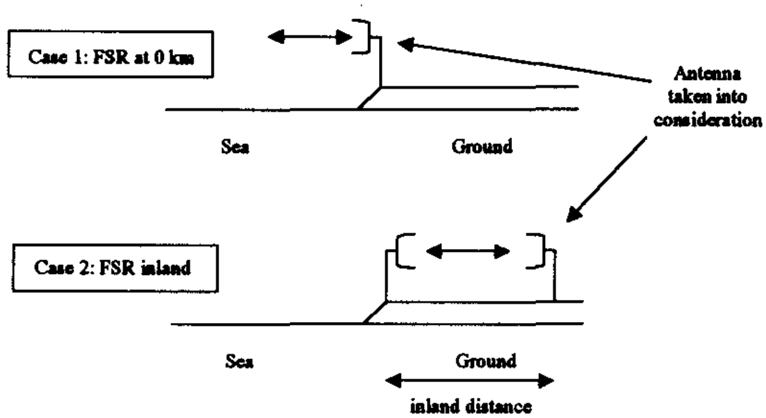


FIGURE 4

Two cases of FSR location

Fixed link receivers located on the coast will generally be pointing inland. However, due to links serving islands off the mainland, there may be links located on or near the coastline which face directly out to sea. The implications of this scenario could be that the off-shore distance should be based on the case of the FSR on the coastline to ensure that all FSRs are protected. However it would be logical to apply the off-shore distance from the coast of the island as well as the mainland. This is illustrated in the Figure 5 below.

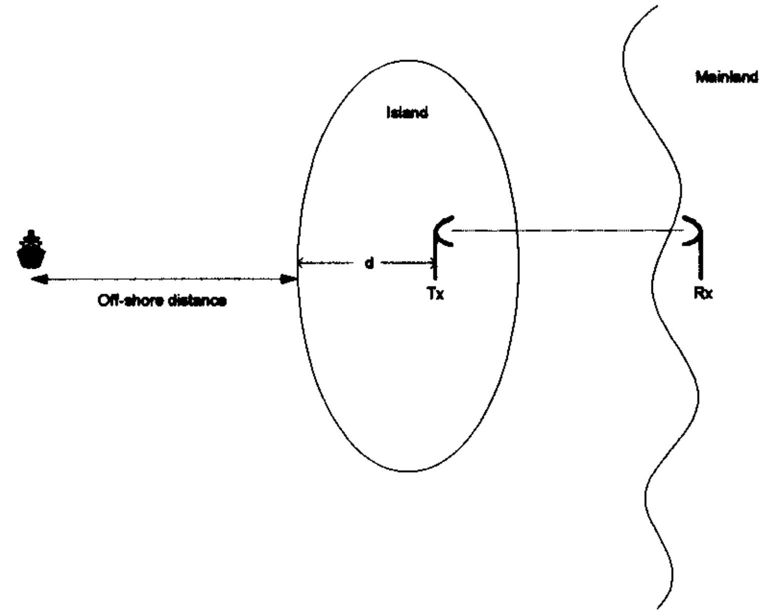


FIGURE 5

FS receiver located on coast serving an island

The figure shows that the distance between the ESV and the FSR is the off-shore distance + the length of the fixed link + **d** the distance from the fixed link transmitter on the island to the coast in the direction of the vessel. Hence even for those fixed links serving islands, there is always an additional distance between the FSR and the coast from which the off-shore distance is applied.

In the Radio Regulations, it would not be practical to apply the off-shore distance to some types of land and not to others. Hence it is reasonable to assume that the distance would be applied with respect to all land, including islands.

3.5 Number of vessels in the 6 GHz band

It is necessary to estimate the number of vessel passes across the beam of the FSR which are received within the receiver bandwidth.

Recommendation ITU-R S.[4/57(Rev.1)] gives some idea of the number of vessels which may currently exist or be predicted for the near future. The number of terminals is extracted below.

System 1	"around 40"
System 2	"around 50"
System 3	"43"
System 4	"around 50"
Total	**about 183**

There are likely to be other service providers which are not included in the Recommendation, but the number of ESVs currently operating can be assumed to be in the low hundreds. These may be assumed to be operating throughout the world. However, it is reasonable to assume that the number of ESVs will increase in the future.

Although it is necessary to consider the likely future growth in the number of ESVs, this depends on a number of factors which are difficult to quantify.

In view of the above, the distances are calculated for a range of co-frequency vessel passes, i.e. one vessel pass every three days, one vessel pass per day and three vessel passes per day.

3.6 Number of vessels in the 14 GHz band

In the band 14.25-14.5 GHz earth stations located on board vessels are likely to be deployed on ferries. Therefore, the number of vessels is likely to be higher than that for the band 5 925-6 425 MHz. Statistics for the United Kingdom indicate that Dover is its busiest ferry port. In 1999 there were approximately 24 000 ferry arrivals, which equates to around 66 ferries per day. The number of vessel passes per day is therefore estimated at 132 passes per day. If the ESV emissions are evenly distributed across the entire band, i.e. 14.0-14.5 GHz, the number of vessel passes falling within the band upper 250 MHz can be estimated at 66 passes per day. Assuming one ESV emission at any time in the FSR receiver bandwidth, the number of vessel passes per day becomes 66 × 17/250 or 4.5 per day. In order to retain a balanced degree of conservatism, the minimum distance has been calculated on the basis of three vessel passes per day and six vessels per day.

3.7 Height of FSR

For the calculations in the 6 GHz band, the FSR antenna height is taken as 120 m amsl. Although this is representative of most cases, in some countries fixed links can be located on mountains with an altitude of about 1 000 m. If it is also assumed that the FSR is 25 km from the coast, and pointing out to sea, then the corresponding fixed link transmitter is likely to be at a much lower altitude, and hence the FSR will have a negative elevation angle (of about –2.3°) whereas the elevation angle from the FSR to the ESV at the off-shore distance will be about 0°. Hence additional FSR antenna discrimination will exist.

4 Resulting distances

Using the parameter values and the methodology described above, the minimum distance can be calculated as shown in the tables below.

4.1 Distances for the 6 GHz band

Protection distance in the C band using the Recommendation ITU-R P.620, latitude = 45°

		FSR at 0 km from the coast			FSR at 25 km from the coast (Note 1)		
Antenna discrimination angle		10° (Note 2)	20°	36°	10° (Note 2)	20°	36°
Lb (dB)		170.5	163	156.5	170.5	163	156.5
1 vessel every third day	distance (km)	**420**	**345**	**280**	**375**	**300**	**235**
	p (%)	0.048	0.058	0.071	0.050	0.061	0.077
1 vessel every day	distance (km)	**445**	**370**	**300**	**405**	**325**	**260**
	p (%)	0.015	0.018	0.022	0.015	0.019	0.023
3 vessels every day	distance (km)	**465**	**385**	**320**	**425**	**350**	**280**
	p (%)	0.005	0.006	0.007	0.005	0.006	0.007

Protection distance in the C band using the Recommendation ITU-R P.452, latitude = 45° (ΔN = 50)

		FSR at 0 km from the coast			FSR at 25 km from the coast (Note 1)		
Antenna discrimination angle		10° (Note 2)	20°	36°	10° (Note 2)	20°	36°
Lb (dB)		170.5	163	156.5	170.5	163	156.5
1 vessel every third day	distance (km)	**404**	**328**	**265**	**368**	**294**	**233**
	p (%)	0.049	0.060	0.075	0.050	0.072	0.077
1 vessel every day	distance (km)	**427**	**347**	**283**	**396**	**321**	**258**
	p (%)	0.015	0.019	0.023	0.016	0.019	0.023
3 vessels every day	distance (km)	**445**	**365**	**298**	**420**	**342**	**279**
	p (%)	0.005	0.006	0.007	0.005	0.006	0.007

Protection distance in the C band using the Recommendation ITU-R P.620, latitude = 20°

		FSR at 0 km from the coast		FSR at 25 km from the coast (Note 1)	
Antenna discrimination angle		20°	36°	20°	36°
Lb (dB)		163	156.5	163	156.5
1 vessel every third day	distance (km)	**375**	**307**	**343**	**277**
	p (%)	0.052	0.064	0.053	0.065
1 vessel every day	distance (km)	**391**	**323**	**362**	**293**
	p (%)	0.017	0.020	0.017	0.020
3 vessels every day	distance (km)	**408**	**377**	**378**	**308**
	p (%)	0.006	0.007	0.006	0.007

Protection distance in the C band using the Recommendation ITU-R P.452, latitude = 20° (ΔN = 70)

		FSR at 0 km from the coast		FSR at 25 km from the coast (Note 1)	
Antenna discrimination angle		20°	36°	20°	36°
Lb (dB)		163	156.5	163	156.5
1 vessel every third day	distance (km)	348	283	318	253
	p (%)	0.057	0.070	0.057	0.071
1 vessel every day	distance (km)	364	297	334	267
	p (%)	0.018	0.022	0.018	0.023
3 vessels every day	distance (km)	378	310	347	281
	p (%)	0.006	0.007	0.006	0.007

NOTE 1 - The proposed distances are referred to the coast which means that the distances in columns corresponding to "FSR at 25 km from the coast" represents the distance to the FSR minus 25 km.

NOTE 2 - 10° discrimination only occurs in the improbable case for which the FSR and ESV azimuths are aligned, and the ESV operates at the minimum elevation angle.

When considering the results presented above, attention should be given to the discussion on the parameters values and scenarios in section 3. The recommended minimum distance from the coastline beyond which in-motion ESVs would not cause unacceptable interference to the FS is 300 km.

4.2 Distances for the 14 GHz band

Protection distance in the 14-14.5 GHz band using the Recommendation ITU-R P.620, latitude = 20°

		FSR at 0 km from the coast		FSR at 15 km from the coast (Note 1)	
Antenna discrimination angle		20°	36°	20°	36°
Lb (dB)		155.2	148.7	155.2	148.7
L1 (dB)		19.7	13.2	19.7	13.2
3 vessels every day	distance (km)	165	120	150	105
	p (%)	0.009	0.013	0.009	0.005
6 vessels every day	distance (km)	170	120	155	105
	p (%)	0.004	0.006	0.004	0.006

Protection distance in the 14-14.5 GHz band using the Recommendation ITU-R P.452, latitude = 20° (ΔN = 70)

		FSR at 0 km from the coast		FSR at 15 km from the coast (Note 1)	
Antenna discrimination angle		20°	36°	20°	36°
Lb (dB)		155.2	148.7	155.2	148.7
3 vessels every day	distance (km)	156	111	140	95
	p (%)	0.007	0.009	0.007	0.005
6 vessels every day	distance (km)	160	114	144	98
	p (%)	0.003	0.005	0.003	0.005

Protection distance in the 14-14.5 GHz band using the Recommendation ITU-R P.620, latitude = 45°

		FSR at 0 km from the coast			FSR at 15 km from the coast (Note 1)		
Antenna discrimination angle		10° (Note 2)	20°	36°	10° (Note 2)	20°	36°
Lb (dB)		162.7	155.2	148.7	162.7	155.2	148.7
L1 (dB)		27.2	19.7	13.2	27.2	19.7	13.2
3 vessels every day	distance (km)	210	160	115	195	140	95
	p (%)	0.007	0.010	0.013	0.007	0.010	0.014
6 vessels every day	distance (km)	215	165	115	200	145	100
	p (%)	0.004	0.005	0.007	0.004	0.005	0.007

Protection distance in the Ku band using the Recommendation ITU-R P.452, latitude = 45° (ΔN = 50)

		FSR at 0 km from the coast			FSR at 15 km from the coast (Note 1)		
Antenna discrimination angle		10° (Note 2)	20°	36°	10° (Note 2)	20°	36°
Lb (dB)		162.7	155.2	148.8	162.7	155.2	148.8
3 vessels every day	distance (km)	202	150	106	183	131	87
	p (%)	0.005	0.007	0.010	0.006	0.009	0.014
6 vessels every day	distance (km)	205	155	109	187	136	90
	p (%)	0.003	0.004	0.034	0.003	0.004	0.007

NOTE 1 - The proposed distances are referred to the coast which means that the distances in columns corresponding to "FSR at 15 km from the coast" represent the distance to the FSR minus 15 km.

NOTE 2 - 10° discrimination only occurs in the improbable case for which the FSR and ESV azimuth are aligned, and the ESV operates at the minimum elevation angle.

When considering the results presented above, attention should be given to the discussion on the parameters values and scenarios in section 3. The recommended minimum distance from the coastline beyond which in-motion ESVs would not cause unacceptable interference to the FS is 125 km.